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ABSTRACT

This study evaluated the impact of class size on student performance in two introductory courses at Indiana University-Purdue University (Indianapolis) from 1992-1997. Analyses employed archival records of student enrollment and grade performance. In the first stage of the analysis, class size cutoff points were defined for small, medium, and large sections. These cutoff points were then used to identify courses offered in varying sized formats. Two dependent variables (course grade and successful completion or withdrawal) measured student performance across different section sizes in two courses, Finite Mathematics and Introduction to Sociology. A final analysis compared students in large and small sections as to the likelihood of their enrolling in a subsequent course in the same discipline, as well as their performance in that course. Results showed a small, overall negative impact of increasing class size on student grades and course completion rates, but this impact was not consistent across courses. Interaction was also found between students' prior level of preparation and section size. The negative impact of section size was greater among lower ability students. The study's results are being used by faculty to improve teaching and learning in large lecture sections. (Contains 23 references, 9 tables, and 3 figures.) (DB)

Running Head: THE IMPACT OF SECTION SIZE ON STUDENT PERFORMANCE IN INTRODUCTORY COURSES

The Impact of Class Size on Student Performance in Introductory Courses

Paper Presented at the 39th Annual Conference of the
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Dolores Vura
Editor
Air Forum Publications

The Impact of Class Size on Student Performance in Introductory Courses

Abstract

An analysis was conducted to examine the impact of section size on student performance in introductory courses offered in both large and small section formats. Results show a small overall negative impact: students in large sections did not perform as well in students in smaller sections of the same course. However, the impact was not consistent across courses. An interaction was also found between students' prior level of preparation and section size: the negative impact of section size was greater among lower ability students. The analysis was conducted to support a faculty-led initiative to determine the conditions for success in large lecture sections. It has spurred several quantitative and qualitative follow-up inquiries.

The Impact of Class Size on Student Performance in Introductory Courses

Introduction

Pascarella and Terenzini's (1991) seminal review of the literature on the impact of college on students dismissed in short order the impact of class size on learning outcomes. According to the sixty years of research they reviewed and synthesized, class size does not appear to impact the acquisition of content and skills, regardless of mode of instruction (e.g., lecture or discussion). However, Pascarella and Terenzini acknowledge that class size may affect motivational, attitudinal and higher-level cognitive processes, as suggested by McKeachie (1980, 1990). Recent research on class size supports McKeachie's contention (Litke, 1995; Miner, 1992; O'Shea, 1993; Perrine, et al., 1995; Smith & Malec, 1995). Given the cost-effectiveness of the large-lecture format, an increasing amount of attention is being paid to maximizing both cognitive and affective student learning outcomes in this setting (Benjamin, 1991; Brown, 1994; Buchanan & Rogers, 1990; Geske, 1992; Gibbs & Jenkins, 1992; Gillette, 1996; Lewis, 1994; Magel, 1996; Miner, 1992; Steffens, 1991; Strauss & Fulwiler, 1989; Weimer, 1987; Woods, 1996).

Recent efforts to assess and improve student outcomes in large classes has followed closely the growing body of evidence that supports active learning pedagogies over more passive ones, such as the lecture format (Bonwell & Eison, 1991; Sutherland & Bonwell, 1996). Moreover, several studies have found that student experience in large classes negatively impacts important correlates of student retention, such as student-faculty interaction (Brown, 1994; Smith & Malec, 1995), personalization (Miner, 1992; O'Shea, 1993), and the overall attractiveness of college environments (Mixon & Hsing, 1994).

This paper reports the results of an inquiry and analysis conducted in support of an initiative at the authors' institution to bring together faculty who teach in large lectures in an effort to identify and share best practice.

The goals of this inquiry and analysis were modest and threefold:

1. To establish baseline differences in performance and persistence across large introductory classes in relation to each other and to corresponding classes of smaller size;
2. To determine if there is any notable differential impact of section size on student performance related to student preparedness or other demographic characteristics; and
3. To support a dialog among faculty teaching such courses that helps identify best practices in teaching large and small class sections.

Method

Initial analyses were conducted to determine class size cutoff points for distinguishing small, medium, and large sections. A second stage of the analysis employed these cutoff points to identify courses that were offered through varying sized formats. Student performance in these courses was then compared across different size sections, controlling for student background characteristics. Two dependent variables were used to measure student performance: course grade (measured on a traditional grade-point scale ranging from 0, for a grade of 'F' to 4 for a grade of 'A') and a dichotomous variable indicating whether the student 'successfully' completed the course (completed the course, attaining a grade of C- or better, vs. attaining a grade of 'D' or 'F' or withdrawing from the class prior to completion). A final analysis was conducted compared students in large and small sections as to their likelihood of enrolling in a subsequent course within the discipline, as well as their performance in the next course, controlling for their grade in the initial course.

The analyses employed archival records of student enrollment and grade performance in classes over a six-year period (1992 through 1997). To minimize student background and experience differences, the first analysis (determining class size cutoff points) included only first-year student fall semester enrollments between 1995 and 1997, but included all introductory-level courses (i.e., courses numbered 100 through 199). The second stage of analysis was restricted to introductory level classes that were offered in multiple size formats (either small and medium, small and large, or medium and large), but included all student enrollees, regardless of their class level. However, class level was controlled for statistically in all assessments of student performance in these courses, as were students' age and level of preparation. Level of preparation was determined according to the students' program affiliation. The university admits students into one of three program standings depending on academic background: the least well-prepared students are admitted into a 'preparatory' program; those who meet entrance requirements but are not yet admitted into a specific major program; and students who meet the entrance requirements and are admitted directly into specific schools or programs based on their background and focused interests.

Results

Determining Class Size Intervals

Cutoff points for categorizing class sections into small, medium, and large were determined using the CHAID clustering procedure included within the AnswerTree analytic software (SPSS, 1998). CHAID is a hierarchical divisive clustering method that uses binary splits to divide a sample into successive subgroups based on selecting a predictor variable that maximizes reduction in the unexplained variation of a criterion variable. Although specifically designed for nominal or ordinal predictors, the AnswerTree implementation of CHAID includes a discretizing function that divides a quantitative predictor into ranges of values (i.e., intervals) that are then treated as ordinal categories. For the current analysis, class size discretized to maximize explained variation in the two dependent outcomes: course grade and successful course completion.

Placing no restrictions on the discretizing function, CHAID produced 16 intervals for class size when predicting course grade-point and eleven categories when predicting percent of successful completers. Table 1 summarizes the results of this unrestricted analysis, showing the number and percent of sections represented in each interval and the average of the target (dependent) variable for each interval. Since this analysis is performed at the section level, the cases were weighted by section enrollments.

Table 1. Initial Intervals for Class Sizes with no Restrictions on Number of Categories

Predictor							
Grade Points				Percent of Successful Completers (PSC)			
Size Interval	N of Sects	% of Sects	Avg. GPA	Size Interval	N of Sects	% of Sects	PSC
5-11	134	5.15	2.54	5-15	344	13.01	67
12-15	188	7.23	2.30	16-24	703	26.58	64
16-17	136	5.23	2.19	25-26	185	6.99	68
18-20	204	7.85	2.27	27-28	191	7.22	67
21-22	172	6.62	2.34	29-31	148	5.6	65
23-24	186	7.15	2.44	32-36	145	5.48	65
25-26	183	7.04	2.41	37-45	306	11.57	63
27-28	186	7.15	2.43	46-49	153	5.78	60
29-31	143	5.5	2.26	50-53	136	5.14	62
32-36	145	5.58	2.29	54-114	271	10.25	60
37-45	303	11.65	2.03	115+	63	2.38	57
46-49	153	5.88	2.14				
50-53	136	5.23	2.13				
54-62	134	5.15	2.13				
63-110	130	5	2.18				
111 +	67	2.58	1.95				

AnswerTree's discretizing function does not only take into account the target variable when determining the interval ranges. It also attempts to balance the number of cases within intervals. To determine the class interval sizes for subsequent analyses, we noted drops in both predictor variables at a section size of about 30, and then again in the largest size category. We also determined a slightly lower cutoff point at the upper ranges of the class size distribution to better balance the distribution of enrollments. Table 2 shows that final ranges that were selected, along with the number and percent of sections and enrollments, and the average of each dependent variable within the interval ranges.

Table 2. Final Class Size Intervals Used for Subsequent Analyses

	Sections		Enrollments			
Size Interval	N	%	N	%	Avg. GPA	PSC[1]
5-30	1532	58.9	16510	40.1	2.54	66
31-90	987	38.0	20212	49.1	2.30	62
91 +	81	3.1	4422	10.7	2.19	58
Overall	2600	100.0	41144	100.0	2.26	64

[1]PSC = Percent of Successful Completers (those attaining a grade of C- or better)

Analyzing Student Performance According to Section Size

The second stage of quantitative analysis compared student performance in introductory courses that were offered in at least two of the three size categories. Table 3 summarizes the course and section enrollments according to the disciplines of the courses that were eligible for inclusion. Some of the disciplines had multiple introductory courses eligible for inclusion. For example, Biology has separate introductory sections for majors and non-majors and Chemistry stratifies introductory students according to an initial placement exam. Classes included in the analysis accounted for nearly 35,000 student enrollments over the period 1992 through 1997.

Table 3. Introductory Courses Included in Second Stage Analysis

		Sections				Enrollments			
	Courses	<30	31-90	91+	Total	<30	31-90	91+	Total
Art	1		7	5	12		460	493	953
Biology	2	19	13	18	50	494	503	2012	3009
Chemistry	2	13	10	22	45	145	512	3554	4211
Geology	1	13	7	4	24	253	422	474	1149
History	3	22	80	11	113	546	4000	1282	5828
Mathematics	2	44	139	23	206	1064	7054	3435	11553
Psychology	1	10	16	12	38	257	927	1534	2718
Sociology	1	4	33	16	53	102	1546	3177	4825
Total	13	125	305	111	541	2861	15424	15961	34246

As expected, the distribution of these target courses across the section size categories differs from the more general population of introductory courses included in the prior analysis. Table 4 summarizes this distribution showing the relatively large number of class sections, and especially enrollments, that fall into the largest size category. However, this summary also shows a similar pattern of grade differences across size categories. The percentage of successful completers also follows the same general pattern, but the drop in this measure as section size increases is not as notable.

Table 4. Courses Included in Second Stage Analysis by Size Category

	Sections		Enrollments			
Size Interval	N	%	N	%	Avg. GPA	PSC[1]
5-30	125	23.1	2861	8.4	2.52	69
31-90	305	56.4	15424	45.0	2.44	67
91 +	111	20.5	15961	46.6	2.20	65
Overall	541	100.0	34246	100.0	2.33	66

[1]PSC = Percent of Successful Completers (those attaining a grade of C- or better)

An initial analysis of covariance was conducted to test for the statistical significance of the impact of section size on both course grade-points and percent of successful completers[1] controlling for student background and enrollment characteristics. Specifically, in addition to section size, course discipline, gender, ethnicity (minority and non-minority), and level of preparation (preparatory, general undeclared, or direct school admit) were entered as fixed factors, and age as a covariate. Each of these additional factors were found to be significantly related to the two outcome variables (grade points and percent of successful completers) in separate bivariate analyses. To minimize the complexity of the overall model, only main effects and two-way interactions involving section size were included.

Table 5 summarizes the analysis of covariance results. As with the bivariate analyses, section size and all the other factors and the age covariate had a significant main effect on both

[1] Myers, et al. (1982) demonstrated the validity of using analysis of variance, or more specifically, the F-ratio, to analyze a dichotomous outcome variable.

grade-points and percent of successful completers. Unfortunately, the high correlation between two of the control factors—level of preparation and class level—makes it difficult to accurately estimate marginal means from this statistical model[2]. Therefore, class level was removed from the model and the data reanalyzed to estimate the marginal means for the section size main effect, and the interactions between section size and level of preparation, and between section size and course discipline.

Table 5. Impact of Section Size on Course Grade Points and Successful Completion, Controlling for Background Differences

	Course Grade-Point				Successful Completion			
	Mean Square	df	F	sig.	Mean Square	df	F	sig.
Main Effects								
Section Size	11.40	2	8.26	0.000	119.97	2	5.68	0.003
Discipline	30.62	7	22.17	0.000	243.61	3	11.53	0.000
Level of Preparation	311.16	2	225.28	0.000	3955.62	2	187.17	0.000
Class Level	7.03	3	5.09	0.002	29.42	3	1.39	0.243
Gender	39.66	1	28.72	0.000	128.01	1	6.06	0.014
Minority Status	436.47	1	316.00	0.000	5132.37	1	242.85	0.000
Age (covariate)	701.81	1	508.11	0.000	702.99	1	33.26	0.000
Two-Way Interactions with Section Size								
Discipline	17.80	13	12.89	0.000	141.04	13	10.06	0.000
Level of Preparation	6.63	4	4.80	0.001	97.49	4	6.67	0.000
Class Level	5.49	6	3.98	0.001	44.90	6	4.61	0.000
Gender	0.75	2	0.54	0.580	2.35	2	2.12	0.120
Minority Status	2.93	2	2.12	0.119	21.13	2	0.11	0.895

The main effect for section is slightly mitigated by the inclusion of these control variables. Table 6 shows that the difference in average grade-points between the smallest and largest size sections has reduced from about one-third of a grade point (as shown in Table 4), to about one-fifth of a grade point. On the other hand, the effect of section size on the percent of successful completers increased from four to six percentage points overall.

[2] Very few juniors or seniors are in the preparatory program, and virtually all have been accepted to their degree-granting programs. That is, students' level of preparation increases as they successful navigate through their undergraduate career and into their selected major.

Table 6. Estimated Marginal Means for Section Size Main Effect and Two-Way Interaction Effects

	Grade-Points by Section Size			Pct. Successful Completers by Section Size		
	5 - 30	31 - 90	91 +	5 - 30	31 - 90	91 +
Section Size Main Effect	2.45	2.41	2.25	65	65	59
Level of Preparation						
Direct admit	2.74	2.57	2.05	73	70	52
Undeclared	2.68	2.54	2.02	72	69	53
Preparatory	2.67	2.36	1.72	72	63	41
Discipline						
Art	.	2.46	2.15	69	66	54
Biology	2.29	2.18	2.06	63	63	52
Chemistry	2.06	2.32	2.04	52	68	53
Geology	2.37	2.29	2.28	53	66	66
History	2.39	2.61	2.32	41	67	61
Mathematics	2.41	2.40	2.50	57	58	61
Psychology	2.72	2.43	2.35	70	64	62
Sociology	2.94	2.60	2.29	77	68	63

Table 6 shows a strong interaction effect between section size and level of preparation. This interaction, illustrated graphically in Figure 1, suggests that large sections of classes have a more notable negative impact on students with the lowest levels of preparation. This differential impact appears even when considering the successful completion outcome, suggesting that less prepared students are more likely to withdraw from large sections compared to other students.

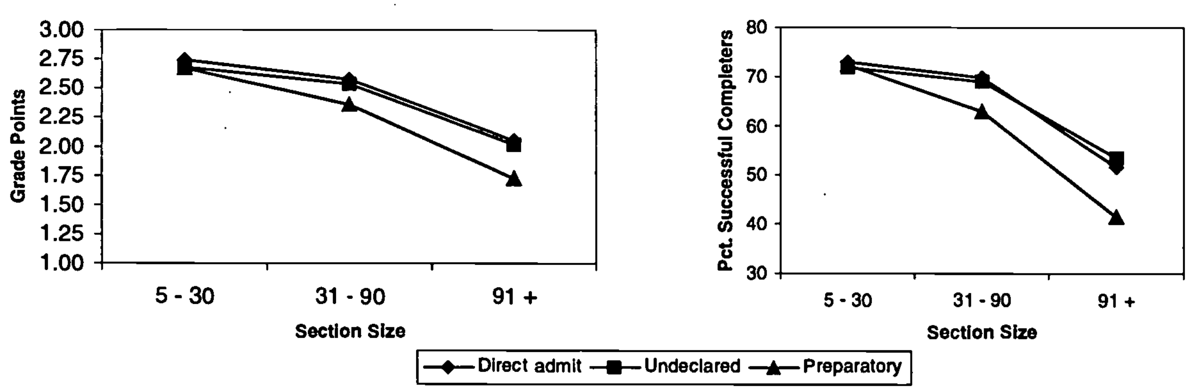

Figure 1. Interactions between Section Size and Level of Preparation.

The bottom portion of Table 6 and Figure 2 suggest notable disciplinary differences in the impact of section size on student performance. Although it is difficult to disentangle these effects, they are important insofar as they suggest important pedagogical differences across the disciplines.

These differences served as the point of departure for discussion among faculty at our institution regarding what types of teaching and learning styles are best suited to the large lecture format. Before exploring in further detail the discussions initiated by these results, we consider the impact of introductory course section sizes on subsequent course taking behavior.

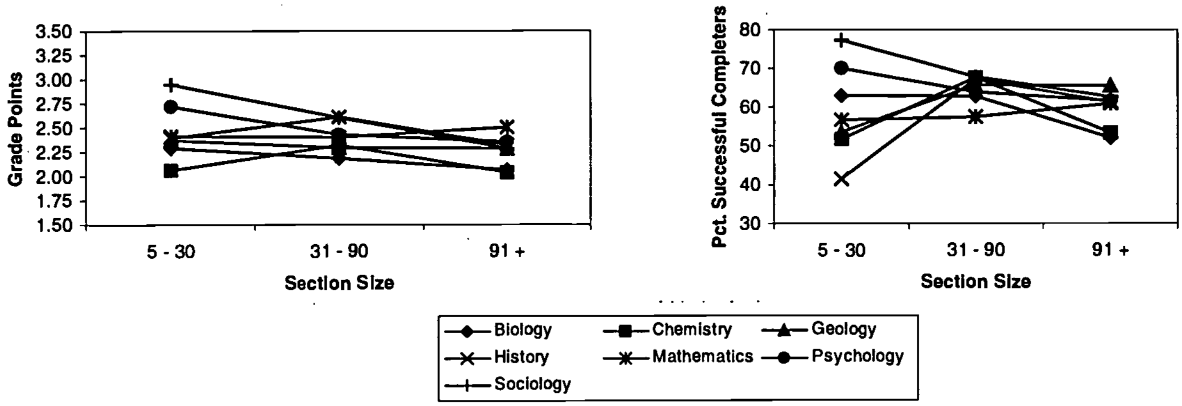

Figure 2. Interactions between Section Size and Course Discipline.

Performance in Subsequent Courses

Introductory courses often serve as a foundation for subsequent courses taken within a discipline. In some cases, taking subsequent courses after the introduction is required as with math course sequences and biology requirements for various health majors. Introductory courses also help students determine their interest in pursuing certain fields of study, either directly in the disciplinary area of the introductory course, or in fields that require sequences of courses in the introductory subject.

To see if section size in the introductory course had an impact on whether or not students enrolled in subsequent courses within the discipline, subsequent enrollments were reviewed for a select set of introductory courses, that is, courses that have relatively high rates of follow-up course taking. One freshmen level course from four different disciplines, Biology, Chemistry, History, and Mathematics, were included in the review of subsequent enrollment. Students who earned a grade of D or F or withdrew from the introductory course were eliminated from the analysis, as these students were likely to re-take the course or dropout altogether. About one-third (34%) of the students were excluded based on introductory course grade or because they repeated the course.

Students in medium-sized sections, followed by large sections of the introductory course were mostly likely to take another course within the discipline when data for all four courses was combined, as shown in Table 7. However, the only course with significant rate differences was Chemistry where students in large introductory course sections were more likely to take another course within the department than were students who had taken small or medium-sized sections.

Table 7. Percent of Students Taking Another Course in the Discipline After the Introductory Course

	Initial Course Section Size				
	< 30	31 - 90	91 +	p.level[1]	Sig.
Overall	43%	59%	51%	0.000	*
Biology	10%	10%	13%	0.215	
Chemistry	31%	33%	41%	0.021	*
History	37%	43%	45%	0.229	
Math	71%	76%	75%	0.101	

Note: Excludes students who repeated the course and students whose grade in the introductory course was D, F, or W.

[1]p.level associated with chi-square test for independence of re-enrolled versus not re-enrolled student by section size (df=2)

Subsequent course enrollments were further limited to a sub-set of follow-up courses to review academic performance based on introductory course section size. Table 8 shows the percent of students who enrolled in one of the specific follow-up courses according to whether students took the introductory course in large vs. medium or small sections. Chemistry was the only course where the rate differences based on introductory course section size was significant. Students who enrolled in large sections of the introductory Chemistry course were more likely to take a follow-up course than were students who had taken small or medium-sized sections. Differences in the rates for Math are approaching significance with a higher percentage of students who enrolled in a medium-sized introductory course enrolling in one of the follow-up courses compared to their counterparts in small or large sections of the introductory course.

Table 8. Percent of Students Taking *Specific Courses* in the Discipline After the Introductory Course

	Initial Course Section Size				
	Less Than 30	31 - 90	91 +	p.level[1]	Sig.
Overall	39%	49%	46%	0.000	*
Biology	9%	8%	11%	0.226	
Chemistry	31%	32%	40%	0.015	*
History	26%	23%	28%	0.207	
Math	66%	70%	67%	0.073	

Note: Excludes students who repeated the course and students whose grade in the introductory course was D, F, or W.

[1]p.level associated with chi-square test for independence of re-enrolled versus not re-enrolled student by section size (df=2)

Finally, Table 9 shows the differences in performance in specific subsequent courses according to introductory course section size.

Table 9. Average Grade and DFW Rate in Subsequent Courses by Introductory Course Size

	Number of Students			Average Grade in Follow-up Course						Completion Rate in Follow-up Course					
Course	< 30	31 - 90	91 +	< 30	31 - 90	91 +	F	p	Sig.	< 30	31 - 90	91 +	F	p	Sig.
Overall	394	2431	1627	2.48	2.35	2.25	3004	0.015	*	85	80	82	3842	0.487	
Biology	28	29	68	2.56	2.85	2.86	90	0.563		98	99	97	101	0.437	
Chemistry	24	97	423	2.86	2.53	2.41	448	0.141		87	89	89	537	0.152	
History	63	519	125	3.21	2.91	2.86	364	0.177		97	96	96	395	0.589	
Math	279	1786	1011	2.30	2.21	2.05	2093	0.021	*	71	68	67	2800	0.064	

Note: Excludes students who repeated the course and students whose grade in the introductory course was D, F, or W.

Differences in the average grade in the follow-up course by introductory course section size are significant for just one of the courses, the Math course. However, these differences were not significant when the grade in the introductory course is taken into account via a one-factor analysis of covariance. That is, it appears that the differences in grades in the follow up course is due to the higher grades achieved by those who took the small introductory course. Moreover, there were no significant differences in the completion rate in follow-up courses according to initial course section size.

Resulting Discussions

The interaction between course discipline and section size and the lack of correspondence in follow-up course taking behaviors, provided points of departure for discussions among faculty regarding teaching and learning in large lecture sections. We here consider two specific cases to illustrate the kinds of actions taken as a result of this study.

Finite Mathematics

A careful look at Table 6 and Figure 2 shows that the impact of section size on math courses appears to run counter to the overall effect. Upon further analysis, a dramatic change over time was found for one of the two math courses included in this analysis. Figure 3 illustrates the successful course completion rate by section size for a particular Math course, Finite Mathematics, during the semesters reviewed. The authors met with the director of introductory level math courses to discuss the change and more generally, efforts within the department to improve student performance.

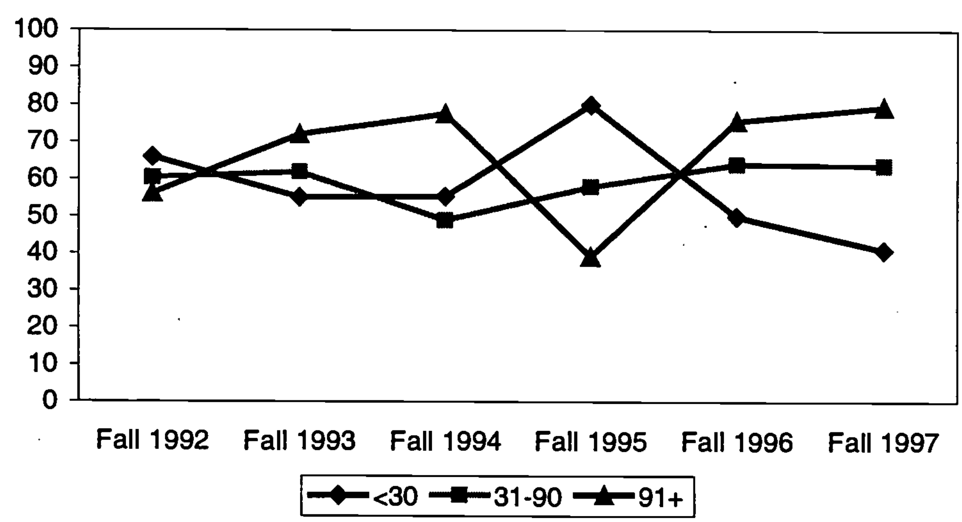

Figure 3. Percent of Successful Completers in Finite Mathematics by Section Size.

The Mathematics department has taken several notable steps to improve student performance in their introductory courses, including the institution of department wide exams, reduction in the number of courses that met only one day per week for an extended time period, and close monitoring of student performance by class section. This last practice led to the dramatic reversal in student performance in large vs. small sections. Specifically, the department intentionally assigned its best instructors to the large lecture sections.

Introduction to Sociology

Attention to the decreasing course completion rates in the introductory Sociology course led to the formation of a committee comprising of full-time faculty who teach the course to address the problem. One of the first objectives of this effort was to establish common course objectives. The committee also designed student questionnaires for use in the assessment of student learning. Students complete a questionnaire at the beginning of the semester that includes items that may impact student performance, such as gender, age, use of childcare, income, motivation, and networking opportunities. This information, along with information collected on a semester end follow-up questionnaire is being used to identify at-risk populations.

Instructors in large sections have taken several other actions to improve student learning in their large lectures. These include asking students questions and asking them to identify themselves when they respond, requiring students to visit the instructor sometime during the semester, taking attendance in class, and using student responses to questionnaires to draw comparisons with national data.

The Sociology Department now plans to re-organize the course, creating a learning community by linking the course to a freshmen-level writing course. Paper assignments in the writing course will be directly linked to the sociology course allowing the student to consolidate course assignments. The department is also moving to computer-based, common examinations across sections. These exams will be held outside of the classroom thereby freeing up class time for additional instruction.

Discussion

Like most of the literature on the impact of class size on student learning, the present study shows mixed results. Section size was shown to have a very modest affect on student grades and course completion rates. Furthermore, section size does not appear to have a direct affect on subsequent course taking behaviors. However, class size does appear to have a greater impact on students who enter college with academic deficiencies. This is an important finding in light of the overall increasing participation rate of underprepared students. In addition this group typically includes a larger proportion of minority and first generation college students.

Studying differences in student performance according to section size and course discipline provides an important lever for institutional change. Faculty at the authors' institution were fascinated by the mixed findings of this study and many became engaged in further inquiry within their own departments. The issues related to section size thus served as a catalyst for broader discussions about teaching and learning among faculty that have gone in several productive directions since.

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